INVIGORATION OF POTATOES BY CROSS-BREEDING

SOME interesting experiments on the potato were tried at Reading last summer. Most persons are aware that changes which are called "improvements" from a commercial point of view have been effected among the plants of the farm and garden in recent years by "hybridising," and that the usual result of hybridising plants is to invigorate them. Mr. Darwin explains the law which horticulturists avail themselves of in the improvement of plants when he says, "All forces throughout Nature tend towards an equilibrium, and for the life of each organism it is necessary that this tendency should be checked" ("Animals and Plants under Domestication," vol. ii. p. 130). He adds, hence "the good effects of crossing the bred, for the germ will be thus slightly modified or acted on by new forces." The invigoration consequent on changing seed corn from one district to another is due to the same causes, as well as the "evil effects of close interbreeding prolonged during many generations, during which the germ will be acted on by a male having almost identically the same constitution."

It would not be easy to ascertain the history of cross-breeding in gardens. Hybridisation has been called "a game of chance played between man and plants." All the great breeders of florists' flowers, and of fruits and vegetables, have practised the art successfully, but as regards the potato recent investigations have shown that the law of "changed conditions" has not been obeyed. The term "hybridising," as used by horticulturists, is a relative expression, referring sometimes to the crossing of widely distinct forms, and in other cases to the injurious union of closely connected forms. Hitherto the breeding of potatoes has involved this vicious principle of too close interbreeding, no other plant of the farm having been more constantly intercrossed.

Some years since the cross-breeding of English and American potatoes was extensively practised, and to some extent, undoubtedly, the "conditions of life" of the varieties which were brought together from either side of the Atlantic were changed; but the cultivated potatoes both of England and America belong to the same species, and having both alike become enfeebled and subject to the same disease, the experiment of interbreeding failed in its object.

Under these circumstances a veteran breeder wrote, "I have come to the end of my tether!" and he gave up the breeding of potatoes in despair. This year he has recommenced it, working hopefully with the aid of a new species, and owing this new departure to the suggestion of the eminent botanist Mr. J. G. Baker, F.R.S., of Kew.

Mr. Baker undertook a scientific examination of the various tuber-bearing species of Solanum, for the purpose of ascertaining whether *S. tuberosum*, the cultivated potato, might not possibly be invigorated by hybridising it with some other species of the family. Writing in the *Journal* of the Linnean Society, Mr. Baker says:—

"The subjects of the differential characters, the relationship to one another, and the climatic and geographical individuality of the numerous types of tuber-bearing Solanums are of great interest both from a botanical and economic point of view. As there are many points which are still to be unravelled, I propose in the present paper to pass in review the material which we possess in England bearing on the question. It was at the instigation of Earl Cathcart that I undertook the inquiry; and in carrying it out I have gone through all the dried specimens at Kew, the British Museum, and the Lindley Herbarium, have carefully studied the wild types which we grow in the herbaceous ground at Kew, and have visited the extensive trial-grounds of Messrs. Sutton and Sons at Reading, whose collection of cultivated types in a living state is probably the most complete in existence."

Bearing in mind that the potato, the most productive of our food-plants, has become the most uncertain among them in regard to its annual produce, it is not surprising that it should have been the subject of voluminous writing and continual inquiry. But, in spite of all the pains which have been expended on this stricken esculent, no one but Mr. Baker seems to have recognised the outrage of in-and-in breeding to which it has been subjected. It seems doubtful whether the numerous breeders were aware that the cultivated potato had been made the subject of continual in-and-in breeding, since it had never been crossed out of its own family during the 250 years of its highly artificial treatment in this country as a cultivated plant. Yet this has been the case, as Mr. Baker shows in his enumeration of the six tuber-bearing species of the plant. As the habitat as well as the distinctions of species of Solanum affect the subject, the following brief details have been taken from Mr. Baker's paper:—

"(1) *S. tuberosum.* Andes of Chili, Peru, Bolivia, Ecuador, and Columbia; also in the mountains of Costa Rica, Mexico, and the South-Western United States.

"(2) *S. Maglia.*—Shore of Chili, down south as far as the Chonos Archipelago; also likely Peru.

"(3) *S. Commersoni.*—Uruguay, Buenos Ayres, and Argentine Territory, in rocky and arid situations at a low level.

"(4) *S. cardiophyllum.*—Mountains of Central Mexico, at an elevation of 8000 to 9000 feet.

"(5) *S. Jamesii.*—Mountains of South-Western United States and Mexico.

"(6) *S. oxycarpum.*—Mountains of Central Mexico."

According to Bentham and Hooker, the great genus of Solanum—the largest in the world—consists of decidedly distinct species, and if we omit some of the so-called species which are really only varieties of *S. tuberosum*, these six species alone bear tubers.

In attempting improvement by crossing the cultivated potato, it is useless to continue the system of interbreeding with its own varieties; and, on the other hand, the lesser forms of wild potatoes, such as *S. Jamesii*, a plant of eight or ten inches in height, must be rejected. Mr. Baker recommends two species as best for the breeders' purpose, *S. Maglia* and *S. Commersoni*. Both these kinds yield good crops of fair quality under cultivation, and they possess the advantage of coming from a moist climate. This is a point of great importance. When Mr. Darwin, a young naturalist in 1835, was writing his account of "The Voyage of the *Beagle*," he mentioned having seen the potato growing wild on the shores of the islands of the Chonos Archipelago, in South America, and he thought it surprising that the same plant should be found in the damp forests of those islands and on the sterile mountains of Central Chili, where a drop of rain does not fall for more than six months. The explanation of this anomalous circumstance is that the potato of the islands and lowlands belongs to a different species from that of the mountains, the latter being identical with the cultivated potato of Europe and America, while the former is *S. Maglia*, which is at any rate hardy, vigorous, and healthy, and in all respects apparently well suited for crossing with the cultivated sorts. This is the potato which Mr. Baker recommends. Earl Cathcart had asked him for any suggestions that a botanist might be able to offer to breeders founded upon scientific knowledge of the potato generally and of the geographical distribution of the family.

On this part of his inquiry, Mr. Baker observes that potato-growers work upon the assumption that the one purpose of the plant's existence is the production of potatoes, which is in fact only an incident in its life. *S. Maglia* has been grown at Kew among the herbaceous plants since 1862, and in that dry sandy soil, without manure, it produces few if any tubers, or only of small size. On the other hand, two tubers were sent to Chiswick and grown there in the gardens of the Royal Horti-

cultural Society in richly-manured land, and the produce proved abundant, yielding, the first year, 600 tubers as large as pigeons' eggs. The constitutional effects of the abnormal production of tubers which high farming occasions have been often noticed. On this point Mr. Baker says: "Any plant brought to the tuber-bearing state is in a disorganised, unhealthy condition, a fitting subject for the attacks of fungus and aphides."

It frequently happens, moreover, that the cultivated potato loses its power of producing flower and of reproducing itself by means of seed. The illustrious horticulturist, Thomas Andrew Knight, discovered the relationship of tuber to fruit, and demonstrated with great clearness the principle that, in proportion as plants or animals waste in one direction, they must economise in another. Knowing the difficulties that lay in the path, Lord Cathcart intrusted some tubers of *S. Maglia* from the coast of Chili to those eminent potato-breeders, whose collection of varieties Mr. Baker refers to as the largest in the world, Messrs. Sutton and Sons of Reading. After very careful treatment of the tubers, which were about the size of walnuts, the young plants were committed to the open ground, where, making our story as short as possible, they grew vigorously and produced numerous blossoms having white corollas, which are characteristic of wild potatoes, the corollas of cultivated breeds being purple and lilac. But whatever the seed-bearing capabilities of *S. Maglia* may be at Valparaiso and in the Chonos Archipelago, when growing in a state of nature, it did not produce a single seed in Messrs. Suttons' trial-grounds, except in the case of some blossoms which were hybridised. It is needless to describe the particular means by which this delicate operation was effected. It happens, however, that the manipulator was the same veteran breeder who had grown despondent about potatoes until this new departure had been achieved. Last winter he had reached the end of his tether. Since then he has hybridised *Solanum Maglia*, and is anticipating the conquest of new potato worlds in his old age.

The crop at Reading this first year is good, and the tubers are as large as those of ordinary potatoes. The foliage is luxuriant, growing as high as a common table. Certain other sorts have shown no capacity for "improvement." *S. Jamesii*, for example, grows at Reading only eight or ten inches high, and would scarcely be recognised as a potato except by a botanist. *S. Commersoni*, known by the synonym *Ohroudi*, from the name of a French naval surgeon who brought it to Brest from Goritti Island, at the mouth of the Rio de la Plata, was obtained last spring by Messrs. Sutton from M. Blanchard of the Gardens of the Naval Hospital at Brest. Messrs Sutton have wisely acted throughout these trials under scientific advice, and *S. Commersoni* had been named by Mr. Baker as one of the few species which are known at present to have shown a capability of "improvement." Unfortunately it resisted all the attempts that were made last summer at Reading to hybridise it with the cultivated sorts. We may hope, however, to become possessed of this and other hybrids before breeders have travelled far on the road which has now been opened to them. Previous attempts to overcome the potato disease had been mainly directed to the doctoring of the soil, or plant, and to direct attacks upon the disease. Every gardener and farmer may now welcome the birth, so to speak, of a hybrid, which, we may hope, will enable the potato plant to resist the attack of parasites, and especially those of the devastating fungus *Peronospora infestans*. H. E.

ON THE EVOLUTION OF THE BLOOD-VESSELS OF THE TEST IN THE TUNICATA

IT is well known that the test or outer tunic in most Simple Ascidians is penetrated by a system of tubes containing blood. These "vessels" were shown in 1872 by Oskar Hertwig [1] to be developed as ectodermal evaginations containing prolongations from one of the blood-sinuses of the underlying mantle. Each vessel is divided longitudinally into two distinct tubes by a septum of connective tissue, and after ramifying through the test may be found to terminate, generally close to the outer surface, in one or more rounded enlargements or bulbs which are usually known as the "terminal knobs" (Fig. 5, B). The two blood-tubes join in the terminal knob where the septum ends, and this allows the blood which flows outwards through the one tube to turn in the bulb and flow back

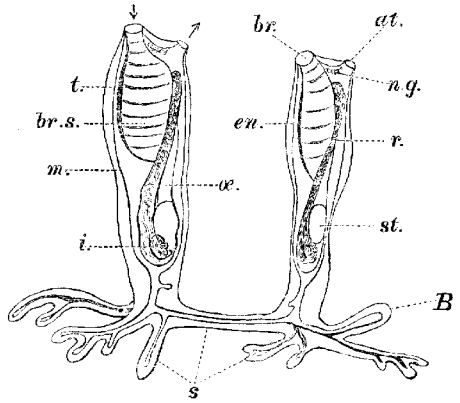

FIG. 1.—*Clavelina lepadiformis*. Enlarged from a specimen dredged off Dartmouth. *br.*, branchial aperture; *at.*, atrial aperture; *br.s.*, branchial sac; *t.*, test; *m.*, mantle; *œ.*, œsophagus; *st.*, stomach; *i.*, intestine; *r.*, rectum; *en.*, endostyle; *n.g.*, nerve ganglion; *s.*, stolon; B, part of the stolon becoming enlarged to form a bud.

along the other tube. Thus temporarily the one tube acts as an artery and the other as a vein, but of course they exchange functions at each reversal of the heart's action.

This system is usually regarded as being merely the blood-supply to the test; but Lacaze-Duthiers [2] has pointed out that the hair-like projections from the test to which sand-grains adhere in most Molgulidæ, are merely special developments of the terminations of the vessels, and I have suggested [3] that they are also homologous with the vessels in the stolon of the Clavelinidæ from which buds are produced (Fig. 1).

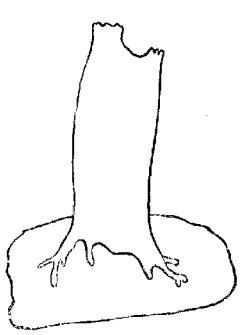

FIG. 2.

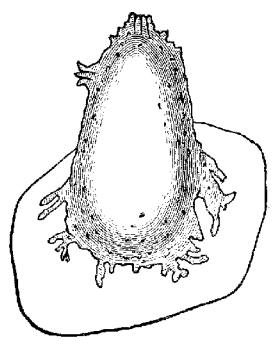

FIG. 3.

FIG. 2.—*Ciona intestinalis* from Lamlash Bay, Arran. Natural size.
FIG. 3.—*Ascidia aspersa* from Lamlash Bay, Arran. Natural size.

The extent to which this blood-system of the test is developed varies greatly in the different species of Simple Ascidians. In some, such as *Ascidia plebeia* and *Corella parallelogramma* (Fig. 4), it is very rudimentary, if indeed it can be said to be present; while in others, such as *Ascidia mentula*, *Ascidia meridionalis*, and *Ascidia*

[1] "Untersuchungen über den Bau und die Entwickelung des Cellulose-Mantels der Tunicaten," *Jenaische Zeitschrift*, Bd. vii. p. 46.
[2] *Archives de Zoologie expérimentale et générale*, t. iii. p. 314, 1874; and *Comptes Rendus*, t. lxxx. p. 600, 1875.
[3] *Proc. Roy. Soc. Edin.* 1879-80, p. 719.